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## Summary

### Problem.

In a recent study of fixed- and rotary-wing aircrew, 30% of E-2C aircrew reported neck symptoms and 38% reported back symptoms within their last 30 flying days. The symptoms included pain, radiating pain, and numbness. The prevalence of neck and back symptoms in these aviators was 25% higher than that seen for attack and fighter jet aircraft and 8% higher than for helicopter aircrews. The Airborne Early Warning community has identified several potential contributors to neck and back symptoms, including (1) cockpit ergonomics, (2) helmet mass, (3) muscle fatigue, and (4) airframe vibration.

### Objective.

The purpose of this study was to determine select characteristics of neck and back symptoms and their origins among E-2C Hawkeye aircrew. These data will be used to establish a database for longitudinal tracking of the prevalence of aircrew neck and back symptoms and to identify and evaluate potential interventions. Such data would be useful in tracking the effect of airframe and engine modifications or changes in missions on humans. The survey included questions on the prevalence, location, and severity of symptoms, flight hours, and other factors that may play a role in neck and back symptoms.

### Approach.

One hundred eighty-five E-2C aircrew members attached to Commander Airborne Early Warning Wing, U.S. Pacific Fleet, NAS Miramar, CA, and to Commander Airborne Early Warning Wing, U.S. Atlantic Fleet, NAS Norfolk, VA, volunteered to complete a neck and back pain and symptoms survey. The mean ( $\pm$  SD) age and hours of flight time for the subjects were 30.6 ( $\pm$  4.3) yr and 1392 ( $\pm$  1003) hr, respectively.

### Results.

Seventy-eight percent of pilots and 74% of Naval Flight Officers (NFO) reported neck and/or back pain in the past year. Similarly, 68% of pilots and 70% of NFO reported experiencing neck and/or back symptoms in their past 30 flying days. Seventy-three percent of

subjects who reported neck and/or back pain classified the pain as "Not at All Severe" or "Somewhat Severe" and 64% indicated that their pain placed "No Limitations" on their job performance. However, 68% of subjects experiencing both neck and back pain classified their pain as "Somewhat Severe" or "Moderately Severe." Furthermore, 47% of subjects experiencing both neck and back pain indicated their pain limited their job performance.

Although the vast majority of the E-2C pilots and NFOs reported they perform aerobic exercises (94%), calisthenics (73%), and resistance exercises (62%) on a regular basis, this did not seem to affect their susceptibility to neck and/or back pain. No relationship was found between the type or frequency of exercise performed and frequency or severity of pain.

### Conclusion.

There is a high incidence of in-flight, transient pain in E-2C aircrew that is similar in nature to that experienced by rotary-wing pilots. Physical conditioning programs do not appear to have any beneficial or exacerbating effects on the symptoms, suggesting that an exercise program would not be a practical remedy to reduce the incidence of neck and back symptoms in E-2C aircrew.

## **Introduction**

Both fixed- and rotary-wing aircraft pilots experience acute and chronic neck and back pain that is associated with flight operations (Shanahan, Mastroianni, and Reading, 1985; Burmeister and Thoma, 1986; Woodruff and Conway, 1994; Feith et al., unpublished data). Shanahan et al. (1985) found that 50% of helicopter pilots studied reported transient pain associated with flights. The pain was described as a dull ache, localized in the lower back, and lasting less than 24 hr. Burmeister and Thoma (1986) found that 65% of propeller-driven aircraft pilots reported backaches, with most feeling that flying duty caused health problems.

A preliminary study by Feith et al. (unpublished data) found that 30% of E-2C aircrew reported neck and back symptoms within the last 30 flying days. The symptoms included pain, radiating pain, and numbness. The prevalence of neck and back symptoms in these aviators was 25% ( $p < 0.05$ ) higher than that seen for attack and fighter jet aircraft and 8% (not significant) higher than for helicopter aircrew.

The preliminary data from Feith et al. (unpublished data) on the prevalence of neck pain in E-2C aircrew suggested the need to investigate the origins of these symptoms. Because the E-2C is a propeller-driven airframe, the induced vibration patterns are more similar to those experienced in a helicopter than in a jet aircraft; therefore, the etiology of the symptoms may be similar. Acute neck and back pain and symptoms during and following flights in the E-2C may result from poor posture, seating ergonomics, vibration of the aircraft during flight, total number of flight hours, or some combination of these factors. A major concern is that the neck and back symptoms in E-2C aircrew could be a precursor to developing chronic back pain, other back disorders, and, ultimately, disability (Bowden, 1985).

## **Methods**

The Naval Health Research Center Committee for the Protection of Human Subjects approved the protocol and procedures used in this study. The E-2C Aircrew Neck and Back Pain

and Symptoms Survey (Appendix A) was approved for distribution by the Navy Bureau of Personnel (Pers 00H) and assigned OPNAV Report Control Symbol 6410-2. The anonymous survey was administered to the squadrons attached to Commander Airborne Early Warning Wing, U.S. Pacific Fleet (COMAEWWINGPAC), NAS Miramar, CA and Commander Airborne Early Warning Wing, U.S. Atlantic Fleet (COMAEWWINGLANT), NAS Norfolk, VA from June 1997 to December 1997.

The survey was divided into four sections. The first section included questions about the subject's personal information and flying history. The next section asked about the subject's experiences/history of neck and back symptoms during the past year. Section three dealt with specific neck and back symptoms experienced within the last 30 flying days, and the last section asked about his/her exercise habits. The exercise information was collected because COMAEWWINGPAC had specifically requested that a physical training program be developed to ameliorate the neck and back symptoms experienced by E-2C aircrew. Surveys were administered in squadron areas. Aircrew were allowed as much time as needed to complete the survey. The on-site survey administrator reviewed each survey as it was returned, checking it for completeness and legibility.

## Results

### Subjects.

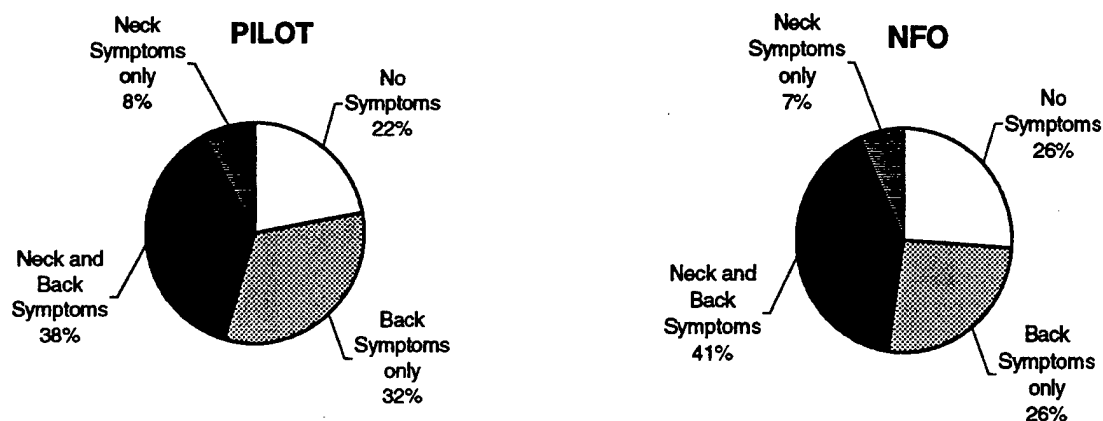
One hundred eighty-five volunteers completed and returned the neck and back pain survey. All subjects were active-duty E-2C pilots (PILOT) or Naval Flight Officers (NFO). Subject demographics are presented in Table 1.

**Table 1. Subject demographics.**

		Age	Height	Total flight	Gender		Rank				
		(years)	(cm)	(hr)	Male	Female	O-1	O-2	O-3	O-4	O-5
PILOT (n = 78)	Mean	29.9	178.0	1475	92.3%	7.7%	0.0%	5.2%	79.2%	11.7%	3.9%
	S.D.	3.6	8.1	1208							
NFO (n = 107)	Mean	31.2	179.2	1332	97.1%	2.9%	0.9%	12.3%	52.8%	28.3%	5.7%
	S.D.	4.6	7.6	822							
TOTAL (n = 185)	Mean	30.6	178.8	1392	95.1%	4.9%	0.5%	9.3%	63.9%	21.3%	4.9%
	S.D.	4.3	7.8	1003							

### Neck and Back Symptoms in the Past Year.

As seen in Figure 1, a high percentage of both PILOT and NFO groups indicated that they had experienced neck and/or back symptoms in the past year, with the highest percentage of subjects reporting both neck and back symptoms.

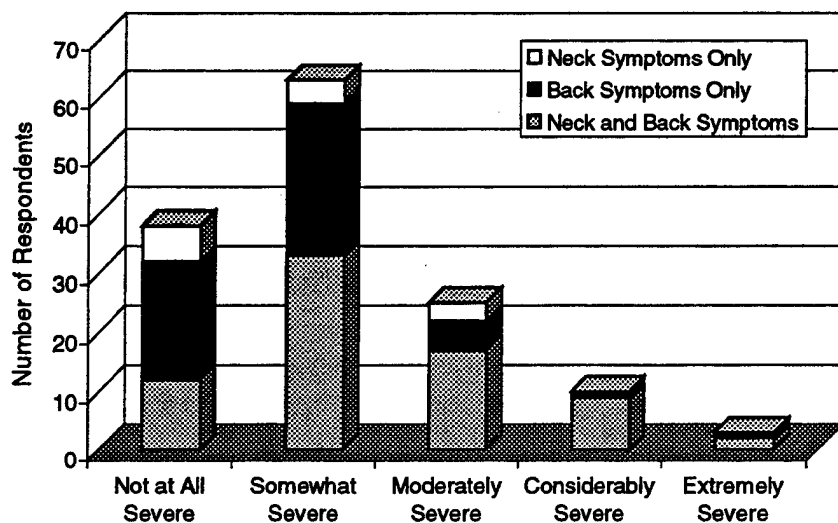


**Figure 1. Reported neck and back symptoms over the past year.**

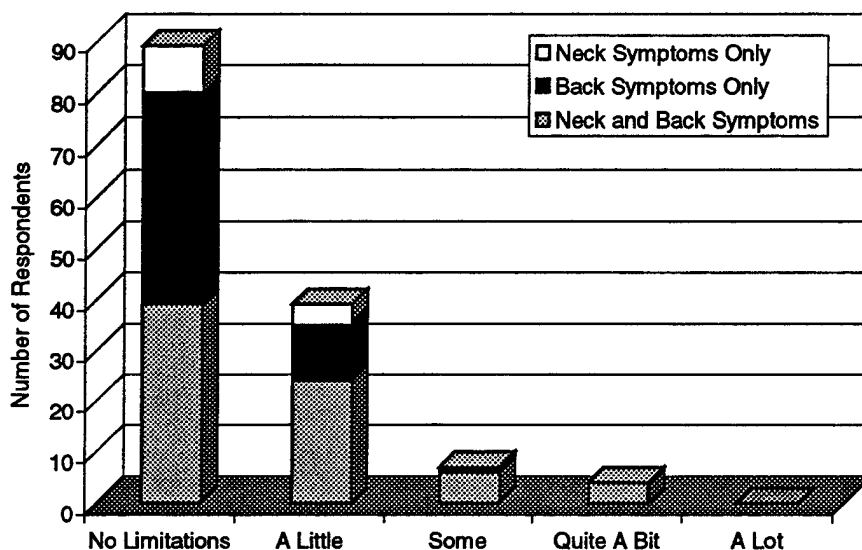
When asked to rate the severity of the pain they had experienced in the past year (Figure 2), 45% of the subjects who had experienced neck and/or back symptoms classified the pain as “Somewhat Severe” and 27% classified it as “Not at All Severe.” It is interesting to note that 74% of the subjects reporting a pain severity of “Moderately Severe,” “Considerably Severe,” or “Extremely Severe” experienced both neck and back symptoms in the past year. In the group that experienced both neck and back symptoms, more subjects reported pain as “Somewhat Severe” or “Moderately Severe” than “Not at All Severe.” None of the subjects experiencing only neck symptoms reported the pain as “Considerably Severe” or “Extremely Severe.”

Sixty-four percent of subjects who reported neck and/or back symptoms in the past year reported that the pain did not limit their job performance (Figure 3). Again, the subjects who reported both neck and back pain show a different profile than those reporting only neck or only

back pain. Twenty-four percent of the subjects experiencing only neck or only back pain report limitation of their job performance, but 47% of subjects experiencing both neck and back pain report a limitation on job performance.



**Figure 2. Pain severity over the past year.**

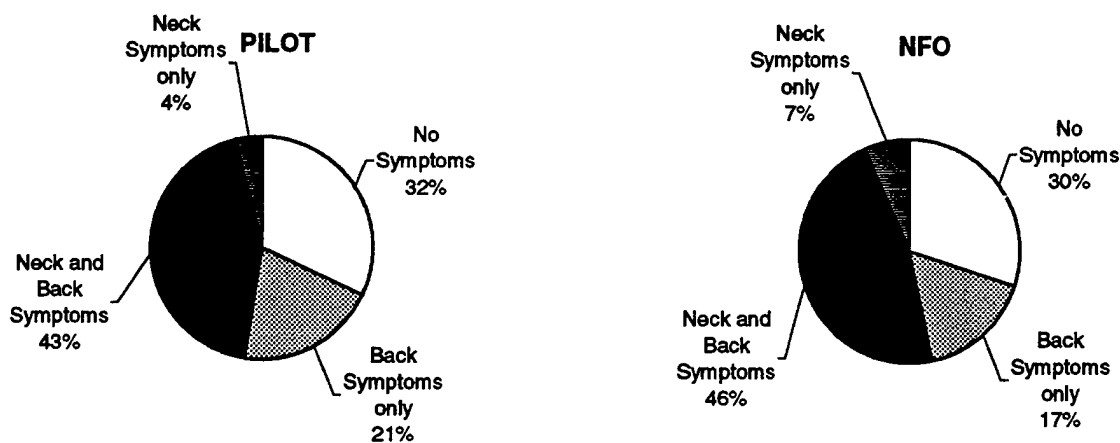


**Figure 3. Pain limitations on job performance in the past year.**



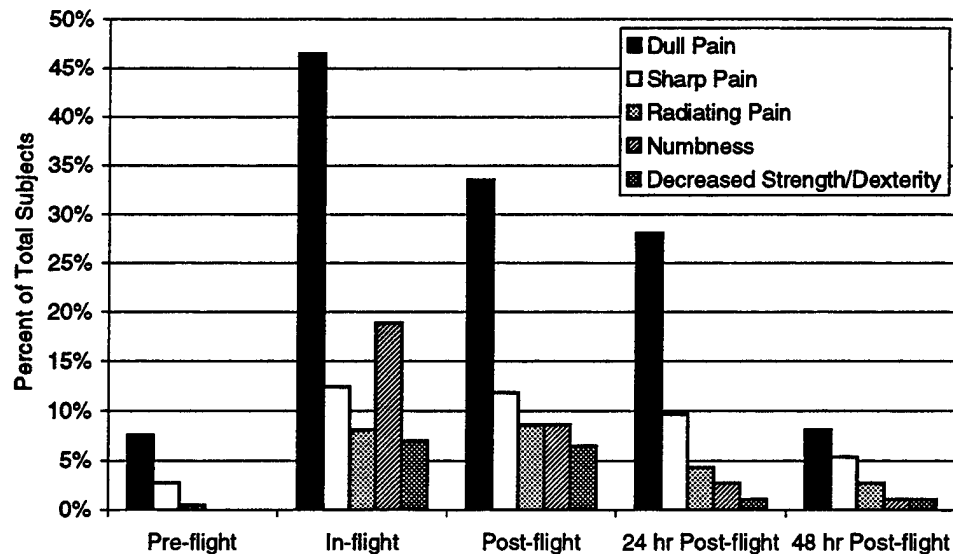
### Neck and Back Symptoms in the Last 30 Flying Days.

Data from the PILOT and NFO reports of neck and back symptoms over their last 30 flying days can be seen graphically in Figure 4. When compared with the data in Figure 1, there are more subjects reporting that they did not experience neck and/or back symptoms in the last 30 flying days than there were reporting no neck and/or back symptoms in the past year. Of those subjects reporting symptoms, 37% experienced symptoms only once in their last 30 flying days, but 17% reported experiencing symptoms in over half of their flights.



**Figure 4. Neck and back symptoms experienced in the last 30 flying days.**

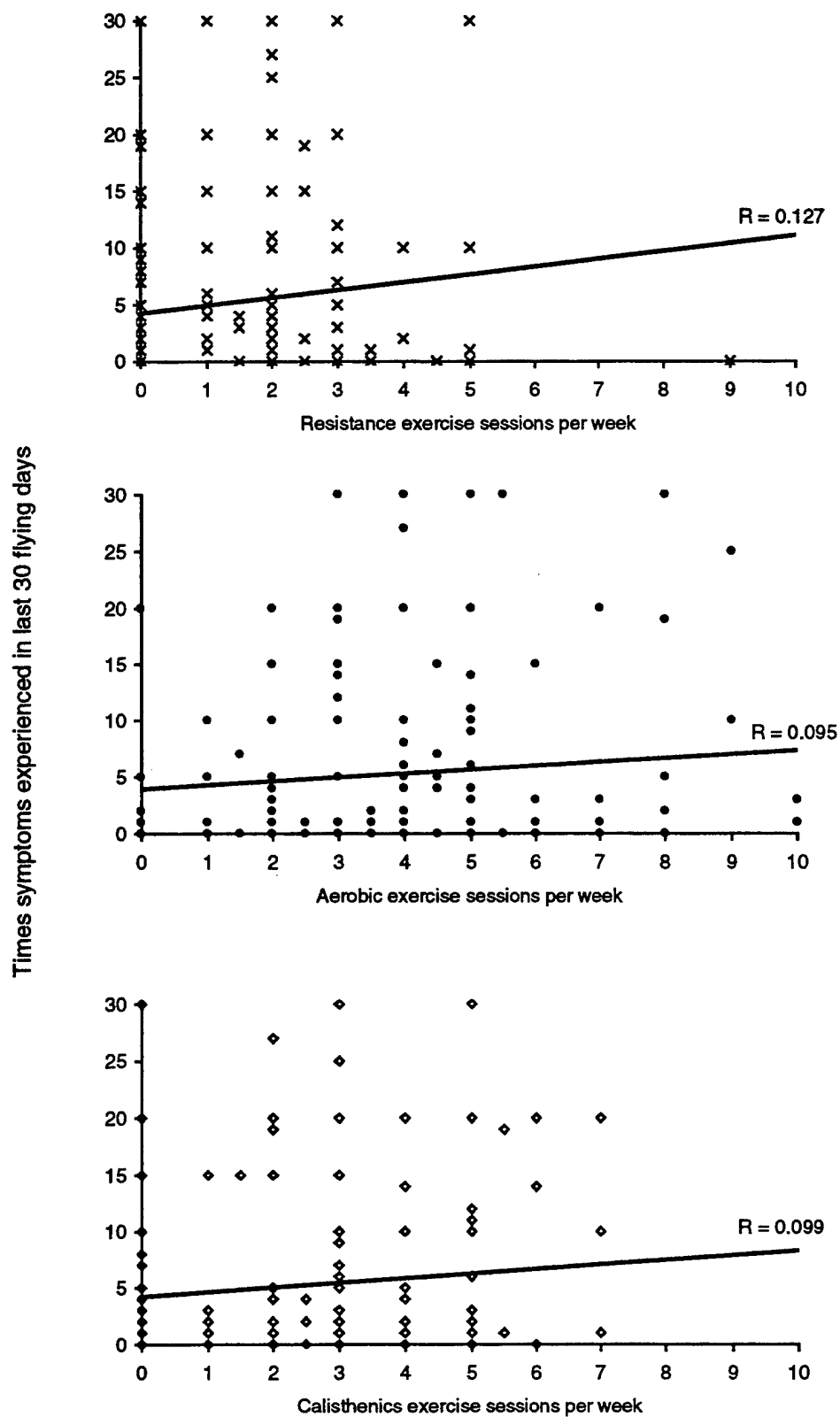
The timing, prevalence, and nature of neck and back symptoms experienced by the E-2C aircrew members in their last 30 flying days can be seen in Figure 5. The most common time for experiencing symptoms was in-flight, and the most common symptom was a dull ache. It is interesting to note that the second most common symptom experienced in-flight was numbness in the extremities, a symptom that could present a serious threat to the safety of the aircrew members during flight.



**Figure 5. Timing, prevalence, and nature of neck and back symptoms in the last 30 flying days.**

#### Exercise Habits and Neck and Back Symptoms.

When the subjects were asked to report their current exercise habits, 94% reported they perform aerobic exercise (e.g., running, swimming, biking) on a regular basis, 73% reported they perform calisthenics (e.g., push-ups, sit-ups) on a regular basis, and 62% reported they perform resistance exercise (e.g., weightlifting) on a regular basis. The subjects also reported that their neck and back symptoms generally were not present during exercise. As can be seen in Figure 6, no significant relationship exists between the type or frequency of exercise performed and the frequency of symptoms in the last 30 flying days. Also, there was no significant relationship found between the type or frequency of exercise performed and the severity of the pain experienced in the past year.



**Figure 6. Relationships between exercise habits and symptom frequency.**

## Discussion

The results of this study suggest that E-2C aircrew experience transient symptoms associated with flight that are similar to the symptoms experienced by helicopter pilots. The most common symptom experienced by E-2C aircrew was dull back pain that occurs in-flight and lasts less than 24 hr. This is identical to the description of the pain experienced by the helicopter pilots reported by Shanahan et al. (1985).

The 70% of E-2C pilots and 67% of NFO reporting back symptoms in the past year are both greater than the 51% of U.S. Navy personnel that Woodruff and Conway (1994) reported having ever had a back problem, but is similar to the 72.8% of Army helicopter pilots reporting back discomfort over a 2-year period (Shanahan et al., 1985). The 64% of E-2C pilots reporting back symptoms in their last 30 flying days also is similar to the 65% of propeller-driven aircraft pilots that Burmeister and Thoma (1986) reported suffer from in-flight back pain. Finally, the 46% of the E-2C aircrew reporting pain in-flight is much greater than the 13% of all Navy pilots that the Naval Operational Medicine Institute (1994) reports experience in-flight back pain. These data indicate that there is a high incidence of back pain in E-2C aircrew members compared with all Navy pilots and with the Navy population in general, but E-2C aircrew pain reports are similar to those of pilots in other propeller-driven airframes and helicopters.

The E-2C community has identified several potential contributors to this problem, including (1) cockpit ergonomics, (2) helmet mass, (3) muscle fatigue, and (4) airframe vibration. After take-off, the NFO workstations, located in the rear of the E-2C, face 90-degrees to the direction of flight. Therefore, the NFO spend the majority of flight-time bent laterally, to compensate for the aircraft's "nose-up" trim, and forward to see the screens of the equipment they are operating. It has been reported that the helmet substantially contributes to neck and back fatigue for male helicopter pilots (Chaffin and Anderson, 1991), and the fatigue effects of the helmet appear to be enhanced by vibration of the helicopter airframe. E-2C aircrew are required to wear helmets throughout flight, increasing cervical muscle loading that could contribute to the onset of fatigue and pain. The onset of fatigue and associated symptoms could

result in decreased mission effectiveness and, if symptoms are severe, could result in temporary or permanent loss of flight status for these highly trained personnel.

Chronic in-flight vibration may be an additional causative agent of soft-tissue insult and injury to pilots. Delahaye et al. (1982) noted that the vibration frequencies encountered in aviation are in the range for which the human body has the least tolerance. It has been speculated that the effects of repeated vibration, jolt impact stress, and the weight of the helmet may cumulatively or synergistically cause fatigue of the neck and back muscles in helicopter pilots (Hamalainen and Vanharanta, 1992). Given the current flying conditions, the potential exists for similar effects in E-2C aircrew.

The paraspinal muscles exhibit tonic activity while helicopter pilots fly their aircraft. It has been postulated that these continuous contractions could lead to compression of the vertebral discs and contribute to the development of back pain. It also has been suggested that fatigue of these paraspinal muscles may manifest itself as lower back pain rather than as a decrease in the force exerted, as seen with normal muscle fatigue protocols (Bowden, 1986). Evidence of paraspinal fatigue during helicopter operations is based on both increased subjective fatigue response, measured with visual analog scales, and a decreased central power frequency in the electrical activity of the muscles (Bowden, 1986; Pope, Wilder, Seroussi, and Donnermeyer, 1985).

A potential intervention to muscle pain and fatigue is the development of an exercise program to increase muscular strength and endurance. Therefore, the exercise habits of the E-2C aircrew members were assessed in the survey. The E-2C aircrew members in this study meet or exceed the physical training of the general Navy (Conway, Trent, and Conway, 1989; Woodruff and Conway, 1994). Nevertheless, the physical training regime undertaken by these aircrew members was not a suitable preventive measure against their pain. Other investigators have reported the lack of a relationship between exercise habits and in-flight pain reports. Shanahan et al. (1985) and Burmeister and Thoma (1986) found no association between the pain reported during flight and participation in any sporting activity for helicopter pilots or jet- and propeller-driven airframe pilots. Furthermore, Shanahan et al. (1985) found no significant difference in

pain reports between pilots who had never participated in any sports or physical activity and those who reported they were currently participating in three or more sports or physical activities. Finally, Shanahan et al. (1985) found no statistical difference in the self-reported current physical condition of pilots who had reported back pain and those who had not. Therefore, implementing a physical conditioning program to strengthen muscles to delay fatigue onset and alleviate back pain would be an impractical approach for these aircrew members.

A stretching program, as suggested by Delahaye et al. (1982), may be an appropriate alternative strategy for alleviating the symptoms that E-2C aircrews experience in-flight and immediately post-flight. Delahaye et al. (1982) reported that helicopter pilots are twice as likely as the general population to have decreased mobility of the spine, resulting in back symptoms. Implementing a stretching program for the low back could increase the flexibility of the lumbar region and may remedy some of the symptoms the E-2C aircrew experience. Further study of the operational and ergonomic conditions that might be the origin of neck and back pain is warranted. Future studies should evaluate the in-flight muscle strain and the impact of airframe vibration as factors that might exacerbate the problem.

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## 13. ABSTRACT (Maximum 200 words)

The purpose of this study was to determine select characteristics of neck and back symptoms among E-2C Hawkeye aircrew. One hundred eighty-five E-2C aircrew volunteered to complete a neck and back pain and symptoms survey. The mean ( $\pm$  SD) age and flight time were 30.6 ( $\pm$  4.3) years and 1392 ( $\pm$  1003) hr, respectively. Seventy-eight percent of pilots and 74% of Naval Flight Officers (NFO) reported neck and/or back pain in the past year. Similarly, 68% of pilots and 70% of NFO reported experiencing neck and/or back symptoms in their past 30 flights. The most common symptom was an in-flight dull ache, lasting 24-48 hours. Although the vast majority of the subjects reported they perform aerobic exercises (94%), calisthenics (73%), and resistance exercises (62%) on a regular basis, this did not affect their susceptibility to neck and/or back pain. Changes in cockpit ergonomics and the implementation of a stretching program for the aircrew may be the best remedy to the problem.

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